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Poster paper

Personnel safety system design for the photon beamlines at the Diamond Light Source

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Diamond Light Source (DLS) is undertaking a programme of developing additional photon beamlines to be added to the existing facility. Operating in the UK, DLS is subject to the Ionizing Radiation Regulations, (IRR99) and having been elected to follow the path of generic prior authorization, DLS is obliged to implement a personnel safety system that conforms to the Approved Code of Practice. In addition, DLS has strived to apply EN61508 to the management and design of the system. This presentation will explain the constraints, design elements and the process that we have undertaken to implement each new safety system and its incorporation into the existing system.

1. Introduction

Diamond Light Source (DLS) is a 3 GeV electron synchrotron light source that provides intense light to experimental stations to undertake 'world class' research and to support the needs of the industry. The programme of development has been split into phases and has to date included building the facility and seven phase-one beamlines, followed by 14 phase-twobeamlines. A third phase of beamline construction is being planned which would bring the total number of beamlines to 31 by 2017. The personnel safety system (PSS) has been designed to accommodate this progressive development, allowing beamlines to be added incrementally, as required.

2. Accommodating new beamlines

The fundamental design decision in the initial safety system concept reflects the 'break points' in the systems. There are clear operating boundaries where shielding is required to separate systems and these are the natural boundaries of the PSS. Typically, shutters are required at the boundaries, and the control of the shutters is dictated by the readiness of the downstream area to accept the beam. The boundary between each beamline and the storage ring falls at the shielding wall and includes the 'port' and 'optics' shutters. Both shutters have the same radiation blocking properties and either is capable of making the system safe. The port

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shutter is under the control of the storage ring and is associated with the readiness of the storage ring to provide a beam to the beamline. The optics shutter is under the control of the beamline and is associated with the readiness of the beamline to accept the beam. This point forms the intersection between the storage ring PSS and the beamline PSS.

The interface between the two systems consists of:

(i) port shutter status from the storage ring to the beamline,

(ii) port shutter permit from the beamline to the storage ring PSS,

(iii) beam permit from the beamline to the storage ring.

These signals are necessary and sufficient to interface new beamlines to the storage ring and hence each beamline can be designed, installed, commissioned, operated and decommissioned independently.

3. Factors influencing PSS design

There are four factors influencing the structure of the Diamond PSS system as follows:

(i) legal framework in the UK,

(ii) a probabilistic approach to the design,

(iii) adoption of a recognized international standard, EN61508,

(iv) best practice in the industry.

These factors overlap and reinforce a common design policy.

3.1. *Legal framework*

The generation of ionizing radiation in the UK can be undertaken only with the authorization of the Health and Safety Executive. DLS has undertaken to conform to the 'generic prior authorization of accelerators', which allows DLS to generate ionizing radiation provided that the criteria set out in the generic prior authorization are met. They can be summarized as follows.

(i) An engineered safety system is used to prevent exposure to unacceptable levels of radiation.

(ii) The safety system conforms with IRR99 (Ionising Radiation Regulations 1999, Statutory Instrument 1999 No. 3232, Crown), regulation 8 and with its Approved Code of Practice (ACOP, "Working with ionising radiation – Approved Code of Practice, L121 HSE Books).

The practical implementation of the ACOP is a series of components which contributes to the PSS:

(*a*) failsafe displays that show the three stages of readiness for the machine to produce radiation,

(*b*) emergency 'off' buttons within the enclosures,

(*c*) captive key systems available to be used to disable the equipment,

(*d*) engineered search systems using search buttons to dictate a search pattern,

(*e*) the exposure of personnel to ionizing radiation should be kept as low as reasonably practicable.

3.2. *Probabilistic requirements at DLS*

To implement a probabilistic safety model, it is necessary to identify a target probability to which one has to aspire. At DLS, we have adopted a target in line with industrial casualties at work in the UK of one death in 100 000 man-years. Of course, casualties may arise from many different hazards, and so we have grouped the hazards into five different categories and distributed the target equally between them.

(*a*) This allocates the average probability of an employee fatality from a radiation incident at DLS, a probability of 2×10^{-6} per annum.

(*b*) With a target set, we must assess the risks and determine control measures necessary to achieve the target. A hazard identification process is undertaken and a preliminary model generated of opportunities and likelihood of a series of events leading to an outcome. Once sufficient control measures, both PSS and external, have been identified, a detailed model including human factors is developed. This leads to a functional design specification for the PSS. The system is designed to the specification and on completion of the design, the design is validated by comparing the design functions with the requirements. Once the system is implemented, it is tested to the functional design specifications, and hence the system is verified and validated, as required under EN61508.

(*c*) The final stage is to validate the original safety model by collecting statistics for the parameters which were assumed initially.

3.3. *Adopted standard EN61508*

EN61508 (Functional Safety of Electrical/Electronic/Programmable Electronic safety-related systems, BSi) is a generic standard to be applied to safety systems in industry sectors where no industry standard exists. It should be noted that there is no explicit legal requirement to conform to this standard. However, there is a generic requirement to protect employees from harm, and by its adoption it provides a good basis for safe management of risks and further helps to provide documented evidence of due diligence.

EN61508 has the following requirements and features:

(i) management of functional safety, generally defining the management and technical activities of the life cycle of the system,

(ii) life cycle requirements, documentation and activities as defined in the management document,

(iii) informative guidance to appropriate techniques.

The life cycle dictates the processes and documentation that are required to successfully conform to the standard.

3.4. *Best practice*

Best practice, for DLS, has been developed by looking at other comparable facilities and trying to adopt features that suit our application. We have tried to include features that offer robust protection, that are valuable and familiar to our users and conform to our other constraints. Search principles, shutter policy and system architecture have all been strongly influenced by other facilities.